4401 FREQUENCY STANDARD

Instruction, Operation and Application Manual

GLOBAL SPECIALTIES CORPORATION
70 Fulton Terrace, P. O. Box 1942, New Haven, CT 06509

MP MASTER
MA32880

Congratulations!

Welcome to the growing family of Global Specialties Corporation test equipment owners. You have selected a versatile and unique piece of equipment designed for full professional performance. To get the most out of this instrument, please read this manual carefully.

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4401 SPECIFICATIONS

OUTPUTS:	Two outputs, DC coupled, BNC connectors	
	10 MHz DRIVE	50 Ohm TTL-compatible square wave, buffered to drive up to 10 TTL loads, short circuit protected, 20 nsec rise and fall into 50 Ohms
	SELECT DRIVE	50 Ohm TTL-compatible square wave, buffered to drive up to 10 TTL loads, short circuit protected, 20 nsec rise and fall into 50 Ohms
REFERENCE:	TIMEBASE	10 MHz crystal oven oscillator, ±0.5 ppm from 0-40°C, oven temperature 55°C, aging less than 1 ppm/year; internal calibration user-accessible; factory calibrated to National Bureau of Standards via WWVB
CONTROLS:	Power; Frequency Select pushbutton scans output through 1 MHz, 100 KHz, 10 KHz, 100 Hz, 10 Hz, 1 Hz, 0.1 Hz; Multiplier Select multiplies selected frequency x1, x2, or x5	
DISPLAYS:	Eight discrete LEDs indicate selected Frequency decade, selected Frequency LED also serves as power pilot; additional LED indicates Oven Ready	
POWER:	105-135 VAC, 57-63 Hz, 5 VA maximum (215-250 VAC, 50-60 Hz version available)	
DIMENSIONS:	3 x 10 x 7 inches H x W x D (76 x 254 x 178 mm) 2.0 lbs (0.9 kg)	
OP TEMP:	0 - 40°C	
INCLUDES:	Instruction Manual	
STOCK NO:	05-4401	

INTRODUCTION

The 4401 Frequency Standard provides a unique source of discrete selectable precision frequencies which can be used as either a time or frequency standard or as a highly accurate signal source. Use it as an oscilloscope timebase calibrator, as a precision clock source for microprocessors, as a precision reference for time-keeping, frequency counter calibrator, or any other application where a precision frequency standard is required.

The heart of the 4401 is its unique 10 MHz precision crystal oven oscillator. It boasts an accuracy of $\pm$0.5 ppm ($\pm$0.00005%) from 0-40^{o}C. This reference is calibrated at the factory to the National Bureau of Standards through WWVB. An oven ready LED on the front panel indicates when the unit has come up to operating temperature and is locked on to frequency (3-5 min.).

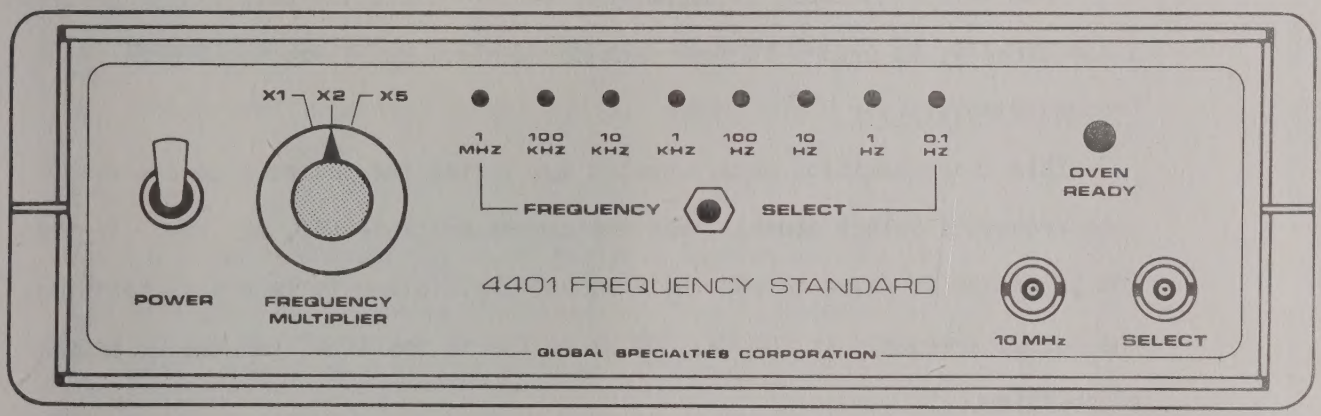
Two BNCs provide the square wave outputs from 10 MHz to 0.1 Hz in 9 decade steps. A Frequency Multiplier control at the front panel enables fractional frequencies of decades in three steps -- 1x, 2x and 5x. For example, if you select the 1 MHz range, frequencies of 1 MHz, 2 MHz, and 5 MHz are available at the Select BNC output.

Both outputs are 50 Ohm, TTL-compatible, square waves and are short circuit protected. A 10 MHz square wave is always present at the 10 MHz output. At the Select output, the available frequency is the selected decade times the Frequency Multiplier (from 0.1 Hz to 5 MHz).

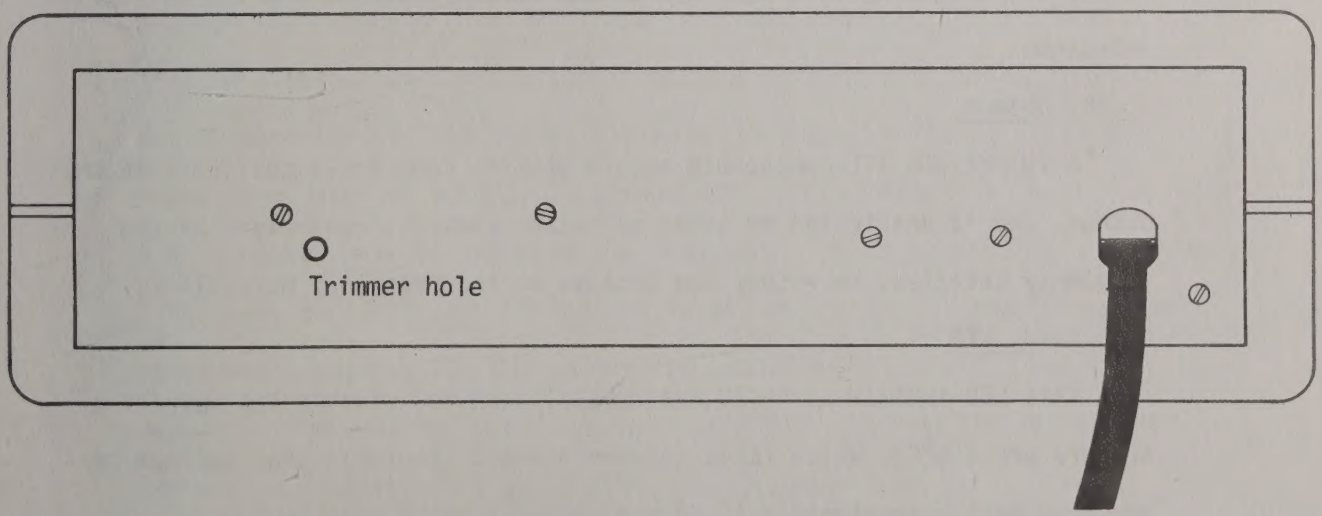
The 4401 is as easy to operate as it is accurate. The only control other than the Power-on switch is the Frequency select pushbutton and a Frequency multiplier switch.

The 4401 is recommended for applications such as the calibration of time and frequency counters, oscilloscopes, and is outstanding as a precision clock source. It is suggested for use in laboratory, test bench, field service, classroom, data acquisition, information processing and communications environments, just to name a few.

Front Panel



Rear Panel



CONTROL LOCATIONS AND DESCRIPTIONS (Refer to Fig 1 for front panel control locations.)

Power

Move the switch marked Power up to turn unit on, down for off. When initially powered, the 0.1 Hz LED will light, serving as a "power on" indicator.

Frequency Select

When this pushbutton is depressed, the eight LED indicators will progress automatically, in order, through each decade (0.1 Hz, 1 Hz, ... 1 MHz).

Frequency Multiplier

This three-position rotary switch multiplies the selected decade range (see Frequency Select above) times the chosen multiple (x1, x2, x5). If the 100 Hz decade is selected and the Frequency Multiplier is in the x1 position, the output frequency is 100 Hz, 200 Hz in the x2 position, and 500 Hz in the x5 position.

Select Output

The frequency available at the BNC output is a 50Ω TTL-compatible square wave. The frequency is a multiple of the decade selected and the multiplier selected.

10 MHz Output

A 10 MHz 50Ω TTL-compatible square wave is constantly available at this output, and is unaffected by other operating controls regardless of the frequency selected, by either the decades or the Frequency Multiplier.

Oven Ready LED

This LED indicates the 10 MHz crystal oven has reached its operating temperature (55°C), which takes between 3 and 5 minutes. (For optimum performance wait approximately 15-20 min. after turning unit on.)

INITIAL INSPECTION AND CHECKOUT PROCEDURE

The following equipment is required:

1. A grounded (three-prong) 50/60 Hz AC outlet of the correct Voltage (110/220 VAC).
2. A frequency counter with a range of 0.1 Hz to 10 MHz (Global Specialties model 6001 or equivalent).
3. Oscilloscope Tektronix model 465, or equivalent.
4. BNC-to-BNC cable (Global Specialties model PSA-2, or equivalent).

Procedure

1. Plug the 4401 into the power outlet. Turn power on. The 0.1 Hz LED will come on. Depress the Frequency Select pushbutton, and the unit will advance through the decades. After about 5 minutes the Oven Ready LED will light up. (For maximum accuracy wait about 15-20 minutes to allow the oven to stabilize.)
2. Connect the 4401 to the frequency counter as shown in Fig 2. Scan through the ranges of the 4401; the frequency counter will track the frequency output present at the Select BNC output connector of the 4401.
3. Now connect the 4401 to the oscilloscope as shown in Fig 3. With the scope terminated at 50Ω, cycle through the 4401 ranges. You will see a 2.5V square wave of the selected frequency. Since period = 1 ÷ frequency, at 10 KHz the period should be 100 μs, at 100 KHz the period should be 10 μs, at 200 KHz the period should be 5 μs, etc. The rise and fall time will be 20 ns. Change the 4401 output to the 10 MHz BNC, and you will observe a 2.5V 10 MHz (.1 μs) square wave.

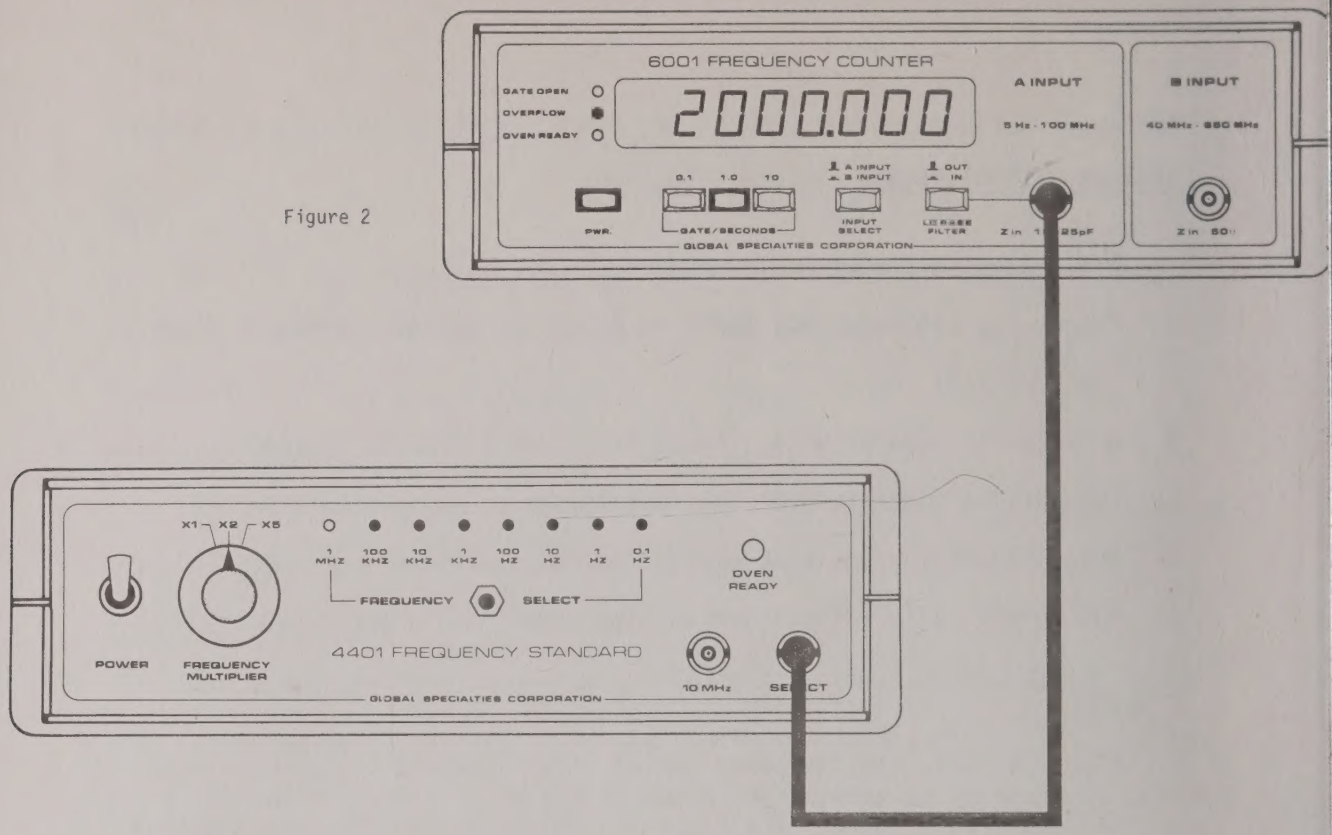


Figure 2

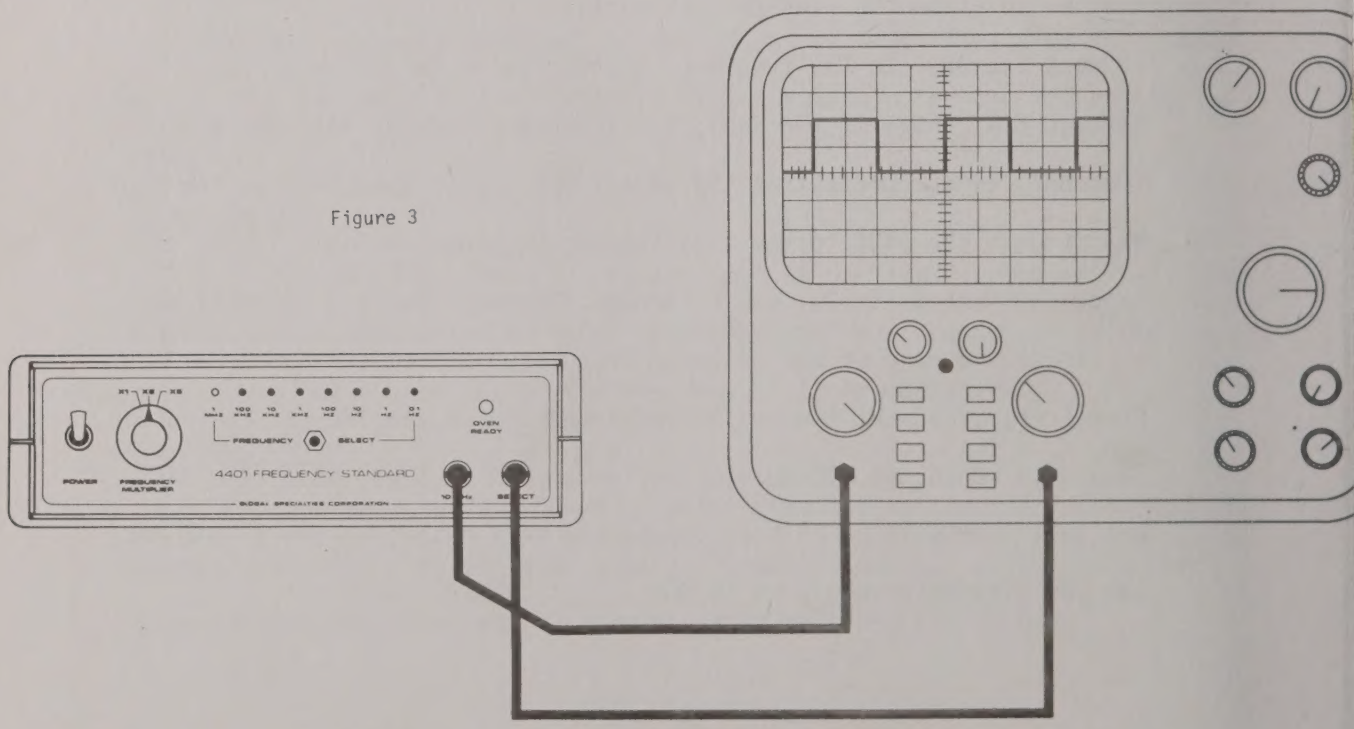


Figure 3

OPERATING INSTRUCTIONS

Precautions

For greatest accuracy wait at least 15-20 minutes after the Oven Ready LED lights before using the unit. Acceptable performance (fully within specifications) is attainable immediately once the Oven Ready LED has lighted, but maximum accuracy requires the additional 15 to 20 minute stabilization time. The 4401 may be left with power on for extended periods to facilitate its immediate use whenever needed.

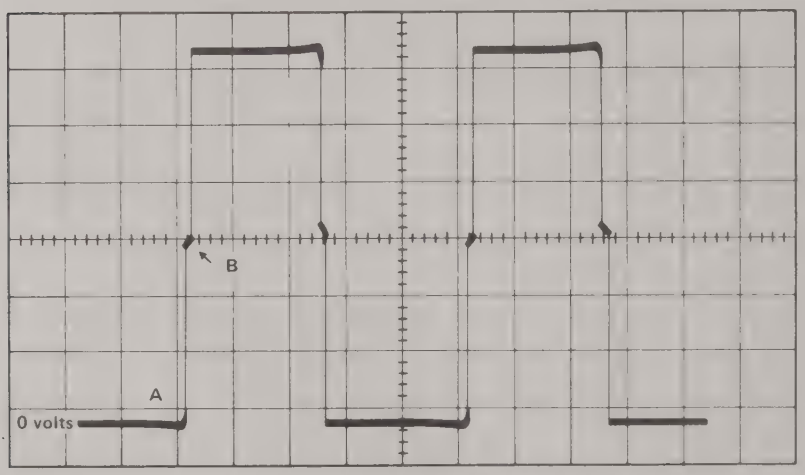
Do not exceed the operating temperature specified for the 4401: from 0°C (32°F) to 40°C (102°F).

Instructions

1. Locate an AC power outlet with an operating Voltage, power frequency and connector compatible with your 4401. Operation with a grounded outlet is recommended.
2. Plug in the 4401 and switch power on by pushing the Power Switch up. The LED in the 0.1 Hz position should light.
3. After approximately 5 min. the Oven Ready LED should light, indicating the oven has come up to temperature. The 4401 will now meet all of its performance specifications. For maximum accuracy a 15-20 minute warm-up period is advised.
4. Select the range you need by depressing the Frequency Select pushbutton, and the 4401 will progress through its ranges. To stop at the desired range simply release the pushbutton when the appropriate LED lights. Now select the Frequency Multiplier (x1, x2, x5) by turning the rotary switch. The product of the Range times the Multiplier is now available at the Select output.

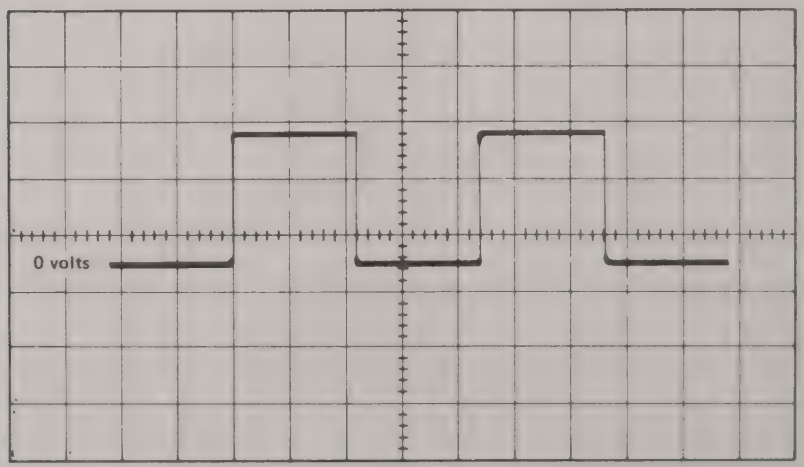
5. A 10 MHz square wave is constantly available at the 10 MHz BNC, regardless of the range or multiple selected.

6. For maximum performance keep all coupling lines as short as possible to eliminate signal degradation. In addition, always terminate all lines into 50Ω. Fig 4a shows an unterminated line. The deviation in the center of the square wave (Pt. B) is the signal reflection at the open end feeding back into the 4401. This may cause false triggering in the circuit under test. Terminating the far end with 50Ω results in the waveform shown in Fig 4b. Matching the far end of the cable with a resistance equal to the characteristic impedance completely eliminates reflections from the far end, resulting in a perfect square wave.



2 μsec/DIV. ⟷

Figure 4a



2 μsec/DIV. ⟷

FUNCTIONAL DESCRIPTION

Fig 5 is a block diagram of the 4401, consisting of 11 sections:

1. 10 MHz "crystal" oven timebase
2. Frequency doubler
3. Bi-quinary divider
4. 10 MHz 50Ω output buffer
5. Switching circuitry
6. 6 decade divider
7. Frequency select circuitry
8. LED drivers
9. 2 flip-flops and a bi-quinary divider
10. Multiplier enable circuitry
11. .1 Hz to 5 MHz 50Ω buffer

The heart of the 4401 is the 10 MHz crystal oven. This accurate signal source is fed into the frequency doubler where the frequency is increased to 20 MHz. The first bi-quinary divider divides the signal down to the proper processing frequencies, 10 MHz square wave for the 10 MHz output buffer. Signals of 20 MHz and 2 MHz are gated through the switching logic to the remaining dividers. The 6 decade selectable divider produces the frequencies from 0.1 Hz to 100 KHz, as well as providing for the LED displays and the strobe for the Frequency Select pushbutton. The remaining circuitry divides down the 20 MHz and the 2 MHz signal to obtain frequencies from 100 KHz to 5 MHz. The Multiplier Enable circuitry chooses the proper division to obtain the x1, x2, x5 multiples, and finally, the 0.1 Hz to 5 MHz buffer processes the signals for the output.

BLOCK DIAGRAM

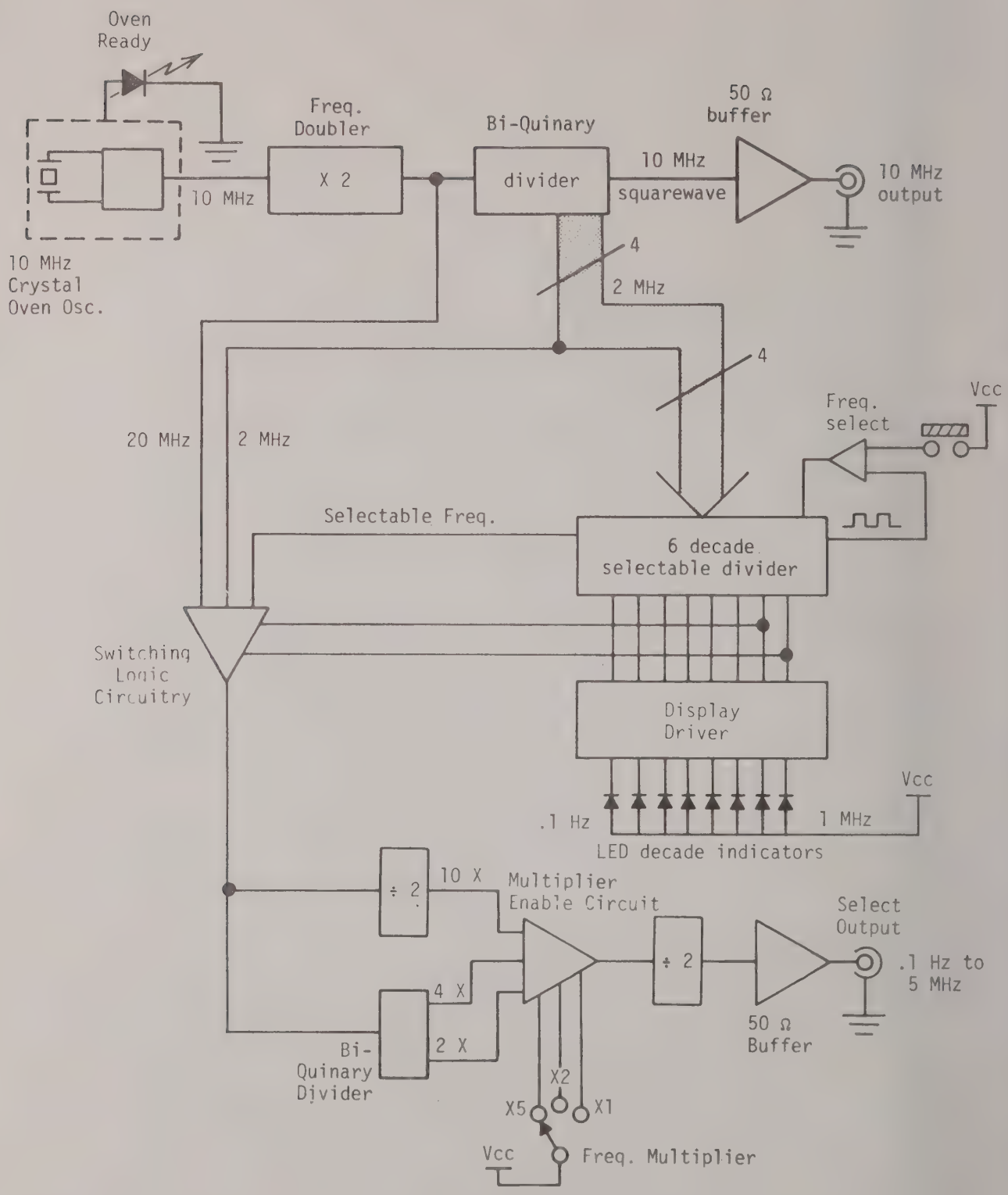


Figure 5

CIRCUIT DESCRIPTION (See Schematic)

The timebase of the Frequency Standard controls the operation of the 4401 and, as such, its accuracy affects the entire Frequency Standard and its performance.

The 4401 uses a unique design to control its timebase by incorporating a specially designed "crystal oven" to precisely control the temperature surrounding its crystal oscillator. The oscillator is kept at a constant 55°C to ensure optimum stability across the entire operating range (0-40°C). Its main temperature sensor (LM-334) is an adjustable current source, and as such, will not induce spurious noise when turned on and off.

The signal from the timebase, a precision 10 MHz sine wave, is fed into the frequency doubler comprised of Q1 and L-C tank circuit, L-1 and C-3, and a buffer Q5. This 20 MHz signal is now squared up by U1 and fed into the first bi-quinary divider U2. U2 divides the 20 MHz by 2 and squares it further, subsequently passing the 10 MHz square wave to U11 and Q2 to provide the 50Ω TTL output which is fed to the 10 MHz output BNC.

U2 also divides the 20 MHz signal from the doubler by 10 to get a 2 MHz signal which is fed both to the 6 decade divider U6 and to the U1 switching circuitry. U6 handles most of the decade division, the strobe functions and display decoding.

By depressing the Frequency Select switch U10 is enabled, allowing a 2 Hz signal to be clocked into the multiplex input of U6. This slowly scans the display driver A-2, lighting the appropriate LED, and enables the internal divider outputs, which are a multiple of the desired frequency, to be fed into the switching logic U5.

The switching logic is a combination of U1, U4 and U5. When the 0.1 Hz to 10 KHz decades are selected, the signal is routed from U6 through U5 to U8 and U7, and then on to U9, where the multiple is selected and passed on

to the 50Ω TTL buffer. When the 100 KHz decade is selected, A2 and U4 enable U1 to pass the 2 MHz squarewave through to either U7 or U8, where it is divided and further passed on to the multiplier select circuitry and finally to the 50Ω TTL buffer.

The same signal processing is utilized with a 20 MHz signal to provide the 1, 2 and 5 MHz outputs.

APPLICATIONS:

Microprocessor clock
Audio testing
Testing transmission lines
Calibration of frequency counters
Calibration of oscilloscopes
Precision signal generator
Frequency counter timebase
Signal generator timebase

The 4401 is a unique, versatile piece of lab equipment, which can be used in a multitude of various applications which require a precision square-wave generator or frequency source. The above list is by no means a comprehensive listing of all its uses; its intent is merely to assist the user with some of its potential applications.

Analyzing a Microprocessor Program:

By substituting your 4401 for the microprocessor system clock you can give your microprocessor the capability of stepping through its micro-program either a step at a time (in 0.1 sec. mode) or at much reduced speed, by using long timing periods such as 10 Hz, 100 Hz, 1K or 10 KHz.

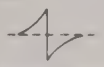
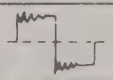
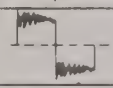
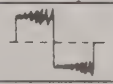
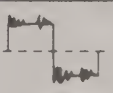
Note, however, that some microprocessors have a minimum clock speed below which correct operation is not assured. If in doubt, check the data sheet for the microprocessor that you are using.

Audio Testing

The 4401 again shows its versatility in testing audio amplifiers. Square waves are used in audio testing to display a wide range of frequencies simultaneously. Square waves consist of a fundamental frequency, and a series of odd harmonics to square off the wave shape.

For an amplifier to reproduce a square wave it must have a flat frequency response from 0.1F to 10F where F is the fundamental frequency of the square wave.

The traditional test frequencies are 50 Hz for the low frequency test and 10 KHz for the high frequency end. Fig 6 shows the typical square wave patterns and an interpretation of these shapes.

Waveform	LF Gain	LF Delay	HF Gain	HF Delay	Damping
	OK	OK	OK	OK	OK
	L	OK	H	OK	H
	H	OK	L	OK	H
	OK	H	OK	L	H
	OK	L	OK	H	H
	H	H	L	L	H
	H	L	L	H	H
	L	H	H	L	H
	OK	OK	H	OK	OK
	OK	OK	H	OK	L
	OK	OK	H	OK	LL
	OK	OK		OK	L

L = Low
LL = Very Low
H = High

Sharp Cutoff or Peaked

Figure 6

Connect the 4401 to the amplifier under test as shown in Fig 7 and observe output on the scope. Fig 8 shows a convenient table of power and Voltage relationships for 4Ω and 8Ω speakers. It also lists the output Voltage level for 10db below the maximum output of amplifiers with different power ratings. Choose the rating closest to the amplifier under test. Testing at 10db below maximum output ensures that the amplifier will not be in saturation. This level is approximately 2/3 of the full power output.

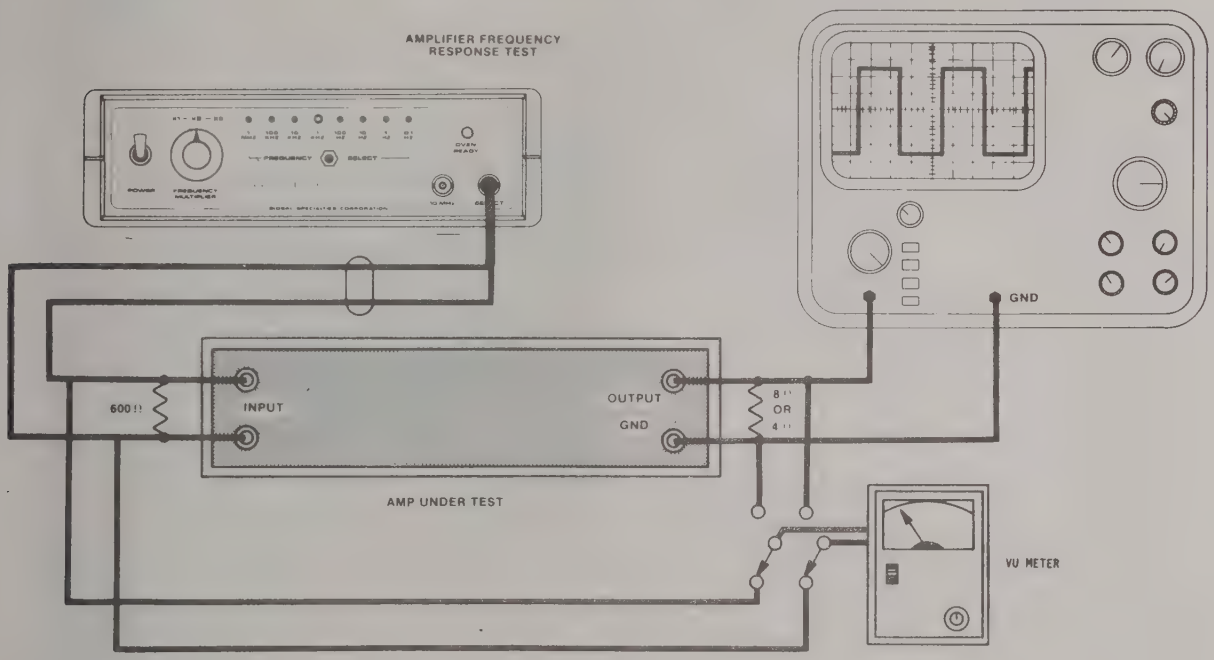


Figure 7

POWER RATINGS (RMS)			OUTPUT (RMS)	
8 Ω	4 Ω	E^2	FULL OUTPUT	10 dB BELOW MAX. OUTPUT
1W	5W	8V	2.8V	2.3V
5W	2.5W	40V	6.3V	5.2V
10W	5.0W	80V	8.9V	7.3V
20W	10W	160V	12.6V	10.3V
50W	25W	400V	20V	16.3V
100W	50W	800V	28V	23.1V

Testing Transmission Lines:

If a transmission line is not terminated at the far end by its characteristic impedance, reflections will occur. This phenomenon can be used to find faults on transmission lines. Using your 4401 you can find out if the cable under test is open, or short circuited, and with some simple calculations you can find the length of the cable.

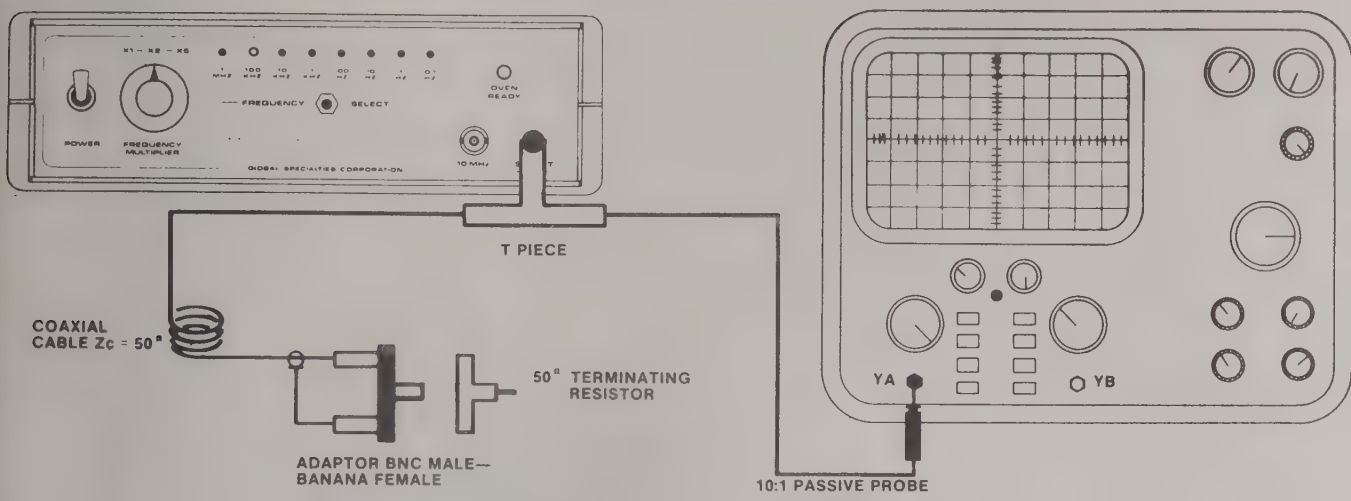
Equipment

1 - 4401 Frequency Standard
1 - 50Ω coaxial cable to be tested (≈10m long)
1 - oscilloscope
1 - passive probe 10:1
1 - 50Ω termination
1 - adaptor banana female - BNC male
1 - BNC T - connector

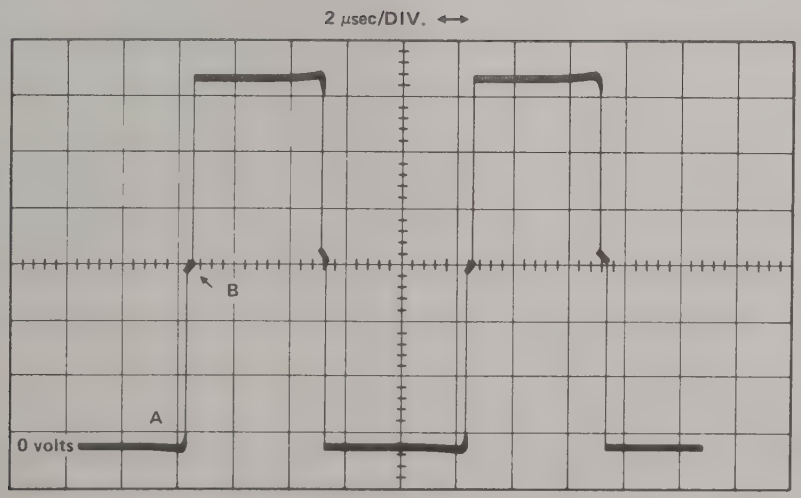
Set up the equipment as shown in Fig 9. Set the 4401 frequency to 100 KHz. Set the scope to:

Vertical Display - 1V/cm
Input Coupling - DC
Trig Source - Int
Trig Mode - Auto
Trig Level - Adjusted
Sweep time - 2μsec/cm

With the far end open, the scope should display a signal shown in Fig 9a. The final amplitude is reached in two steps. At the moment the 4401 meets the 50Ω of the cable itself, the output is at nominal value (midscale dots B on Fig 9a) and a reflection takes place at the open end. When this reflection feeds back to the pulse generator output, it tells the 4401 that the far end is open, and the open circuit Voltage of the 4401 appears.



TRANSMISSION LINE TEST.



Now change the Time/Div of the scope to 0.1μsec and observe the signal in Fig 9b. The time between points A and B is the time that it takes for the missing signal to reach the open end and return. For example, assume that (as in Fig 9b) the reflection takes 120nsec. It is known that the velocity of a signal in a coaxial cable is about 0.7C (C = 3 x 10^8m/sec). If the cable has the length L it will take 2 L/0.7C before the signal returns as a reflection. Using the time observed on the scope the cable length is calculated as shown:

$$T = \frac{2L}{0.7C} \text{ where T is Time for return Reflection}$$

Solving for L we get:

$$L = \frac{0.7CT}{2}$$

$$L = \frac{(0.7) \times (3 \times 10^8 \text{m/sec}) \times (120 \times 10^{-9} \text{sec})}{2}$$

$$L = 12.6 \text{ meters}$$

Remember that the accuracy of this result is determined by the Time-Base accuracy.

Short circuiting the end of the cable results in the waveform shown in Figs 9c and 9d. After 120nsec the 4401 "knows" that its output is short circuited and the Voltage drops to Zero. The cable load influences this ideal behavior and Zero means "almost" Zero, which can be noticed from the offset level with respect to the start.

Terminating the far end with 50Ω results in the waveform show in Fig 9e.

Matching the far end of the cable with a resistor equal to the characteristic impedance completely eliminates reflections from the far end, resulting in a perfect square wave at the generator end of the cable.

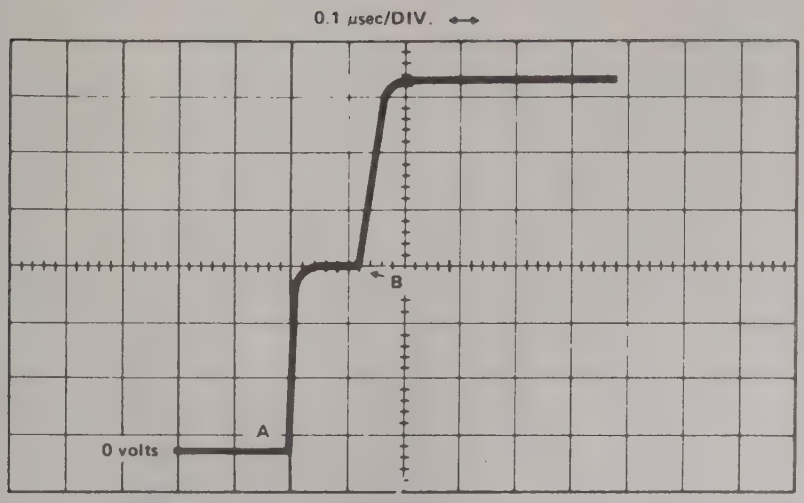


Figure 9b

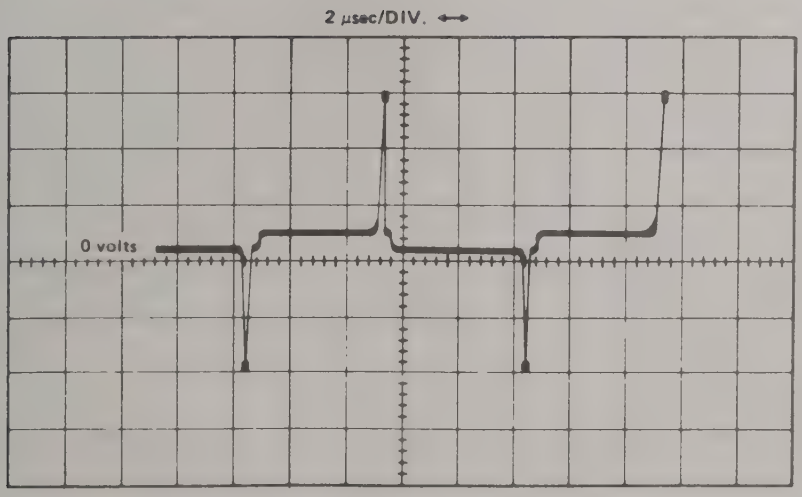
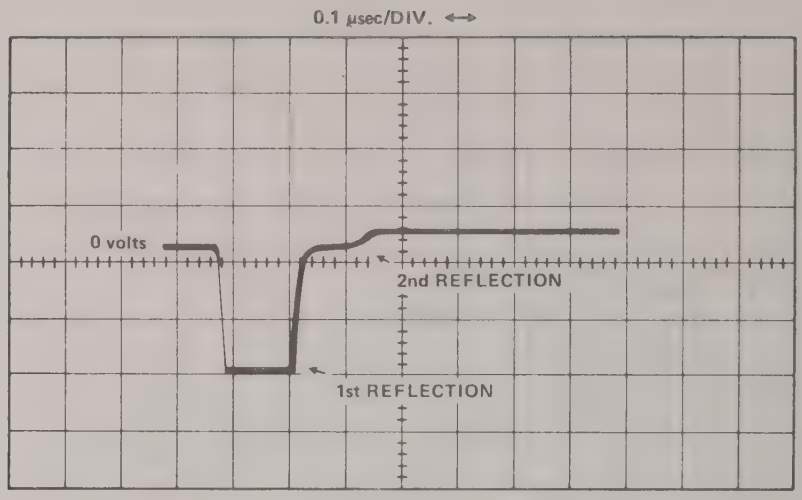
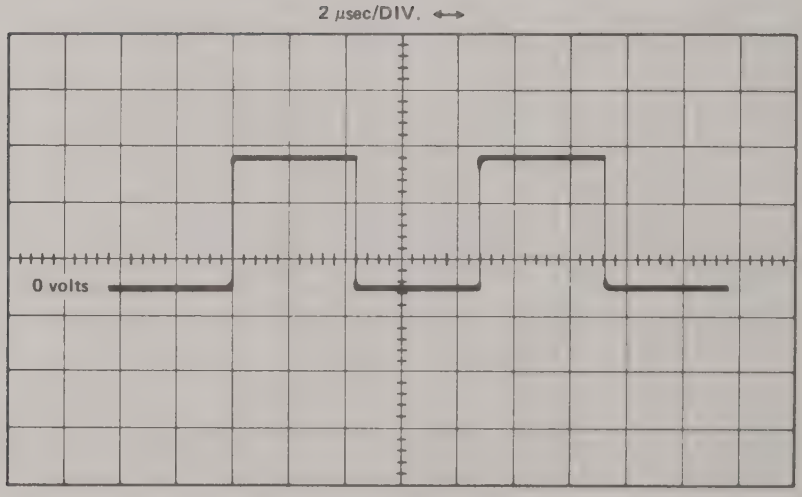


Figure 9c


0.1 µsec/DIV. ↔
0 volts
2nd REFLECTION
1st REFLECTION


2 µsec/DIV. ↔
0 volts

Calibration of Frequency Counters:

With an accuracy of 0.5 ppm, the 4401 can easily be used to calibrate a Frequency Counter.

To start, allow all instruments that will be used an ample warm-up period (approximately 30 minutes). Then simply tie the 10 MHz output to the Frequency Counter's input and adjust the Frequency Counter's time base according to the manufacturer's recommendations.

Frequency Counter Time Base and Signal Generator Time Base:

Many Frequency Counters and Signal Generators have available either as an option or standard an external time base input. This is used when more accuracy is needed than is available with the standard time base. With this feature many orders of magnitude in accuracy can be obtained with an accurate Frequency Generator such as the 4401.

To use the 4401 as such a time base just select the appropriate output frequency (usually 1 MHz or 10 MHz) and tie into the external time base input on the unit and follow the manufacturer's instructions. Remember to keep all cables as short as possible.

Oscilloscope Calibrator:

For calibrating an oscilloscope, most manufacturers recommend that an accurate square wave generator be used in the test. Since most scopes have an accuracy of about 2%, the 4401 is 400 times more accurate and, therefore, ideal for this use. Make sure you follow the manufacturer's suggested calibration procedure.

MAINTENANCE AND CALIBRATION

The 4401 Frequency Standard is factory tested and calibrated to National Bureau of Standards and, as such, requires no initial servicing when purchased. However, since the crystal oscillator will age at a rate of less than 1 part per million per year (<1ppm/yr), the 4401 should periodically be recalibrated. For optimum accuracy and performance this recalibration should be done at the factory with our precision time and frequency standards. (See Figs 10a and 10b for trimmer capacitor locations.)

The 4401 can be calibrated outside the factory if a frequency counter with a clock source of at least ±0.05 ppm is available.

To recalibrate the 4401 follow the procedures outlined below:

1. Remove all connections to the 4401 and disconnect the unit from the AC outlet.
2. Follow the procedures under Case Disassembly.
3. Locate the trimmer capacitor on the main board in the upper left-hand corner with the oven board directly above.

DANGER!

DURING THE FOLLOWING STEPS, POTENTIALLY DANGEROUS VOLTAGES ARE PRESENT AND EXPOSED WITHIN THE INSTRUMENT. DO NOT LEAVE UNIT UNATTENDED IN THIS CONDITION.

4. Plug the 4401 into the AC power outlet and turn power on. Also apply power to the frequency counter you have chosen for this calibration procedure.
5. The 4401 requires a minimum of thirty minutes to warm up and fully stabilize for maximum accuracy; your counter may require an even longer warm-up time. Be certain to allow ample time for the warm-up of both units.

6. Connect the external frequency counter to the 10 MHz output of the 4401. (See Fig 11)
7. Using a non-conductive, non-inductive tuning wand, adjust the trimmer capacitor until the frequency counter reads 10 MHz ± 0.5 ppm (between 9999.995 and 10000.005 KHz). Typically, you should be able to adjust the oven to within ± 0.3 ppm or better. The trimmer on the main board adjusts the doubler circuitry and should only be touched when the duty cycle is suspected to be other than 50-50. Improper adjustment may cause jitter in the output waveform. To adjust the duty cycle, simply use a non-conductive, non-inductive tuning wand to adjust the trimmer capacitor until the duty cycle locks on at 50%.

CASE DISASSEMBLY

Follow these steps any time you wish to open the case of the 4401:

1. Remove any connections from the Input and Output connectors.
2. Remove the AC Power Cord plug from the AC outlet.
3. Turn the 4401 case upside down (feet facing up).
4. Remove the Phillips-head screw completely from the center recess of each of the four feet.
5. Keeping the top and bottom case halves together with light pressure, carefully reinvert the case so it is again upright.
6. Gently slide the upper half of the case straight upward, once clear of the front and rear panels, place it to one side.
7. The component side of the printed circuit board should now be visible, secured to the bottom half of the case and both front and rear panels.

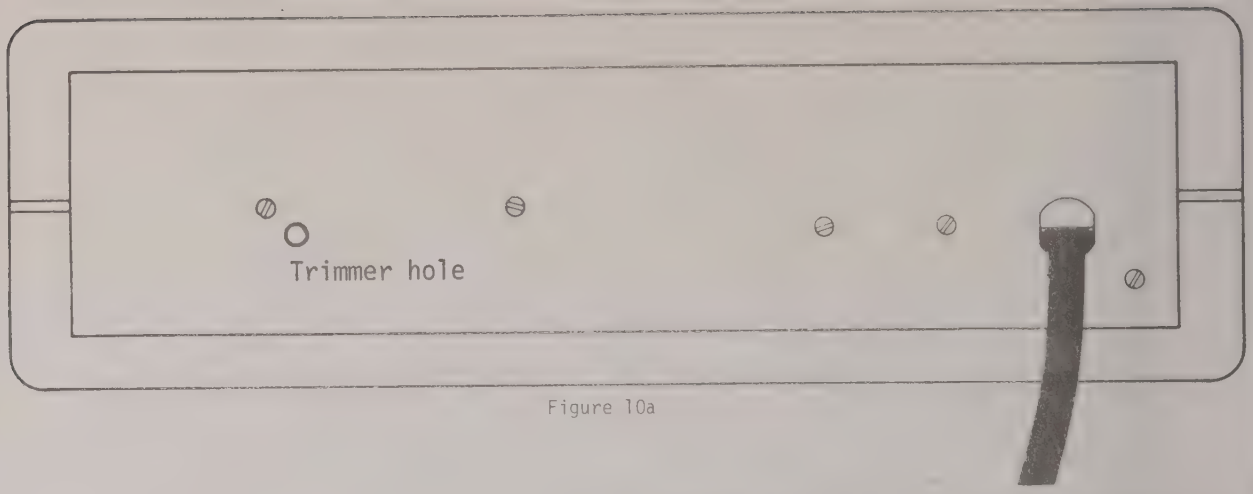


Figure 10a

Oven P.C. Board mounted on Rear Panel

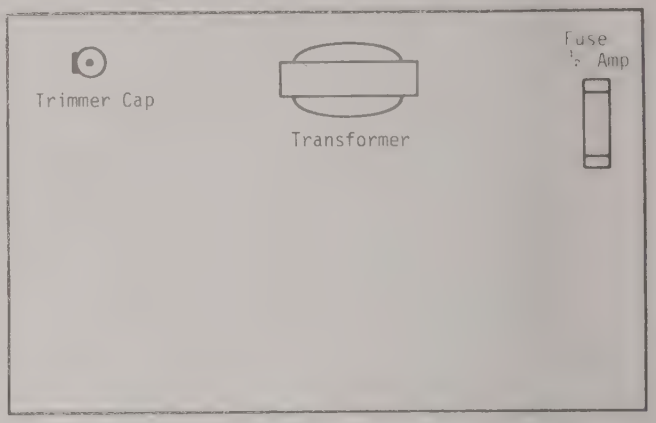
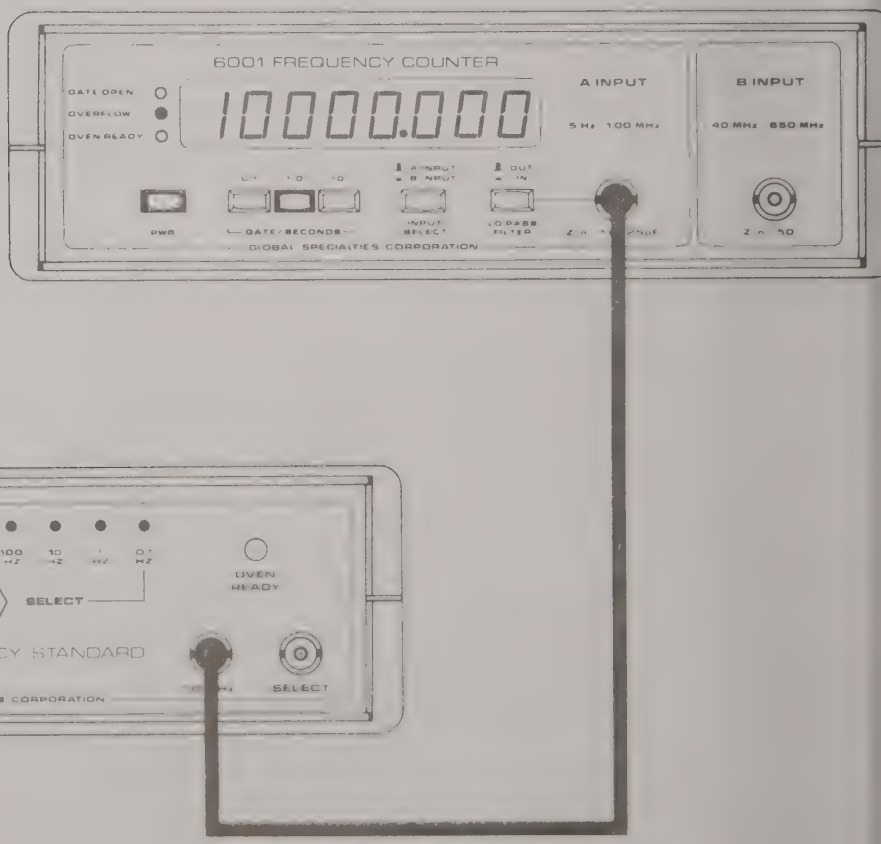
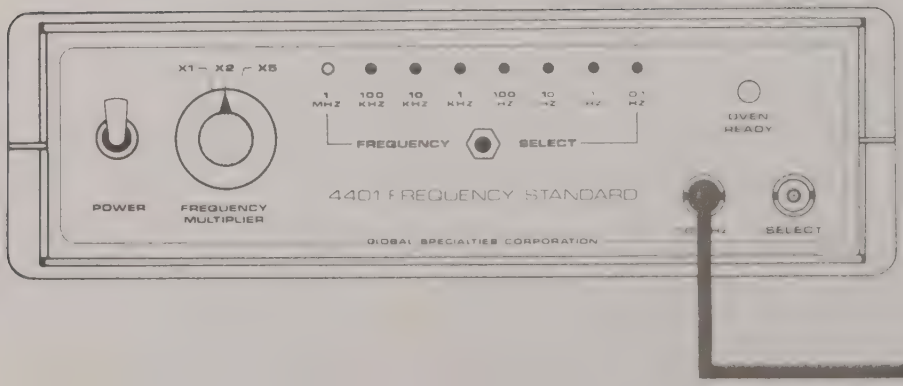


Figure 11





FUSE REMOVAL

A ½ Amp power fuse is located on the main printed circuit board in the upper right-hand corner. If replacement of this fuse becomes necessary, follow this procedure:

1. Disconnect all cables connected into the 4401 outputs.
2. Turn power off.
3. Disconnect the AC line.
4. Open the case, following the instructions under Case Disassembly.
5. To change the power fuse, use a non-conductive fuse handling tool to remove the old fuse from its holders. (Fig 10b)
6. Reassemble the case.

CASE REASSEMBLY

Follow these steps to reclose the 4401 case:

1. Make sure no tools or debris remain inside the case; that all power, input and output connections are removed; and that the printed circuit board and front and rear panels are securely in place.
2. With the bottom half of the case upright, gently slide the upper case half straight down into position atop the lower half; make sure the front and rear panels are in position in the molded case panel grooves. The top and bottom case halves mate when the beveled edges face forward.
3. Once the top case half is in place, keep the case halves together, in position, with light pressure as you invert the 4401 case (placing it upside down, feet up).
4. Make sure all four feet are positioned directly over the holes in the case bottom.

5. Reinsert each of the four Phillips-head screws through the center hole in the recessed area of each foot and through the corresponding mounting holes in the case bottom into the threaded mounting posts molded into the upper case half.
6. Tighten all four screws, being careful not to overtighten.
7. Reinvert the 4401 to its upright position.
8. Reconnect AC power. The 4401 is again ready for use.

FACTORY SERVICE AND REPAIR

Global Specialties Corporation will service and repair this instrument free of charge for a period of one full year (See Warranty). Please return it, shipping charges prepaid, in its original box with a copy of sales slip or original invoice to:

GLOBAL SPECIALTIES CORPORATION
70 FULTON TERRACE
P. O. BOX 1942
NEW HAVEN, CONNECTICUT 06509
ATTN: SERVICE DEPARTMENT

Your instrument will be repaired, retested and promptly returned to you. If it needs servicing and is out of warranty, follow the above instructions and enclose $35.00 for Factory Service. This amount covers most routine repairs; if damage to your unit is extensive, we will advise you of additional costs before proceeding.

WARRANTY

Global Specialties Corporation warrants this device to be free from defective material or workmanship for a period of one full year from date of original purchase.

Global Specialties Corporation under this warranty is limited to repairing the defective device when returned to the factory, shipping charges prepaid, within one full year from date of original purchase.

Units returned to Global Specialties Corporation that have been subject to abuse, misuse, damage or accident; have been connected, installed or adjusted contrary to the instructions furnished by Global Specialties Corporation; or repaired by unauthorized persons will not be covered by this warranty.

Global Specialties Corporation reserves the right to discontinue models; change specifications, price or design of this device at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury which may result from the use or misuse of this device by the purchaser, his employees, or agents.

Global Specialties Corporation shall not be liable in any way for consequential damages resulting from use of this device.

This warranty is in lieu of all other representations or warranties expressed or implied and no agent or representative of Global Specialties Corporation is authorized to assume any other obligation in connection with the sale and purchase of this device.

Specifications subject to change without notice
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NOTES

1. ALL DIODES ARE IN4148 UNLESS OTHERWISE SPECIFIED
2. GND BOTH ENDS OF ALL COAX SHIELDS
3. STRAP 2-3 FOR 230V 1-3 & 2-4 FOR 115V

C47 WILL BE ADDED ONLY AS NEEDED BY Q.C.

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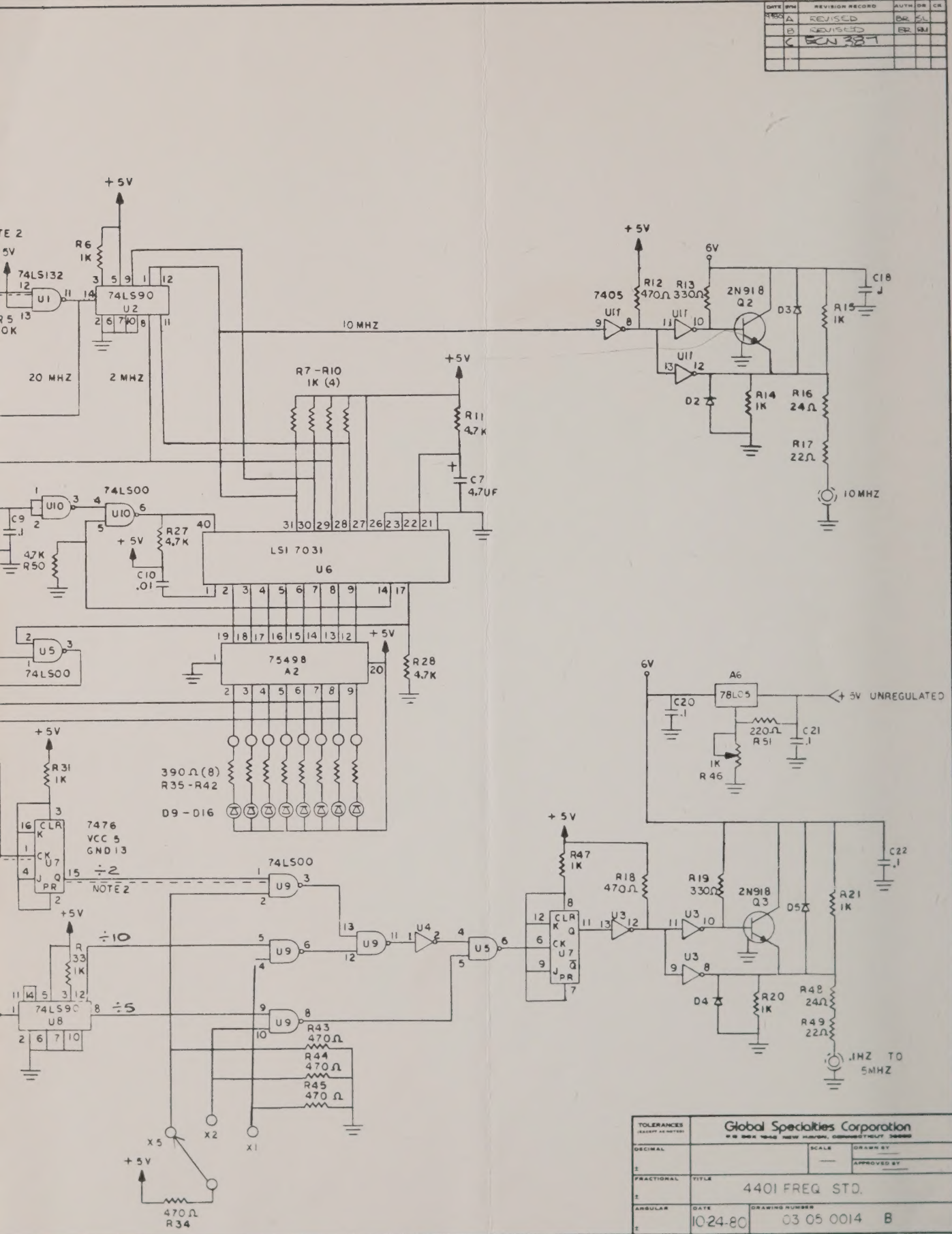
ENGINEERS' STANDARD FORM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74LS90
U2
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20 MHZ
2 MHZ
R7-R10
1K (4)
R11
4.7K
C7
4.7UF
74LS00
U10
C9
.1
4.7K
R50
R27
4.7K
C10
.01
LSI 7031
U6
U5
74LS00
75498
A2
R28
4.7K
R31
1K
390Ω (8)
R35-R42
D9-D16
7476
VCC 5
GND 13
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NOTE 2
÷10
÷5
74LS90
U8
R
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1K
74LS00
U9
U4
U5
R43
470Ω
R44
470Ω
R45
470Ω
X5
X2
X1
470Ω
R34
7405
U11
R12
470Ω
R13
330Ω
2N918
Q2
D3
R15
1K
C18
D2
R14
1K
R16
24Ω
R17
22Ω
10MHZ
6V
A6
78L05
+5V UNREGULATED
C20
.1
220Ω
R51
C21
.1
1K
R46
R47
1K
R18
470Ω
R19
330Ω
2N918
Q3
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C22
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U3
D4
R20
1K
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R49
22Ω
.1HZ TO
5MHZ
TOLERANCES
(EXCEPT AS NOTED)
DECIMAL
±
FRACTIONAL
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ANGULAR
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Global Specialties Corporation
SCALE
DRAWN BY
APPROVED BY
TITLE
4401 FREQ STD.
DATE
10-24-80
DRAWING NUMBER
03 05 0014 B
MADE IN U.S.A.

MP MASTER
MA32880